All-Optical Electrical Chirped Pulse Generation with Tunable Chirp Rate based on a Nonlinearly Chirped Fiber Bragg Grating

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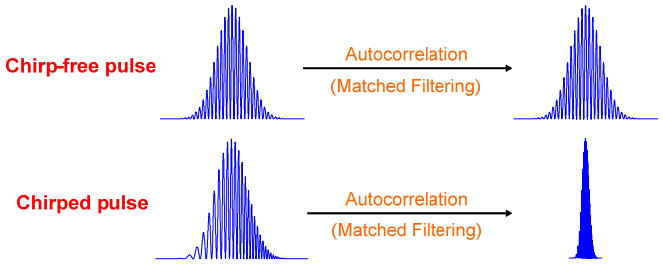
Abstract

In this paper, we proposed a novel approach to optically generating chirped electrical pulses with a tunable frequency chirp using a nonlinearly chirped fiber Bragg grating (NL-CFBG). In the approach, a broadband ultrashort optical pulse is spectrally filtered by two tunable optical filters, with the two filtered pulses applied to the NL-CFBG, to introduce different dispersions. The beating of two differently chirped optical pulses at a high-speed photodetector leads to the generation of a linearly chirped electrical pulse with a tunable chirp rate by easily tuning the center wavelengths of the tunable optical filters. The NL-CFBG used in the system is experimentally produced using a new simple technique based on strain-gradient beam tuning. A mathematical model to describe the chirped electrical pulse generation is developed, which is verified by numerical simulations.

1. INTRODUCTION

Pulse compression using frequency chirped pulses



Applications of chirped electrical pulse:

Radar systems | Communications systems | Instrumentation systems

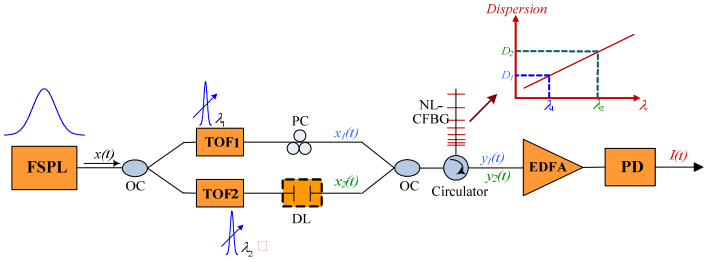
Generation of chirped electrical pulse:

Electrical domain — Low central frequency

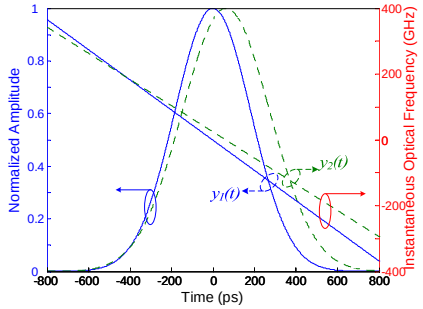
Optical domain — High frequency, large time-bandwidth product, high tunability

2. PRINCIPLE

A. System configuration and theoretical model

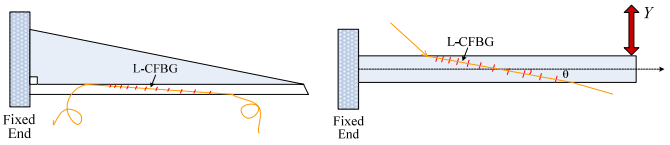


FSPL: femtosecond pulsed laser; **TOF:** tunable optical filter;
DL: delay line; **PC:** polarization controller;
EDFA: erbium-doped fiber amplifier; **PD:** photodetector;
OC: optical coupler.

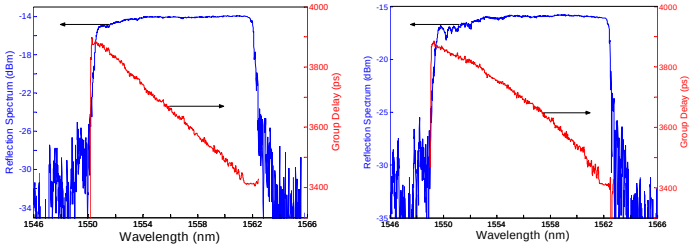


The beating of $y_1(t)$ and $y_2(t)$ leads to the generation of a linearly chirped electrical pulse.

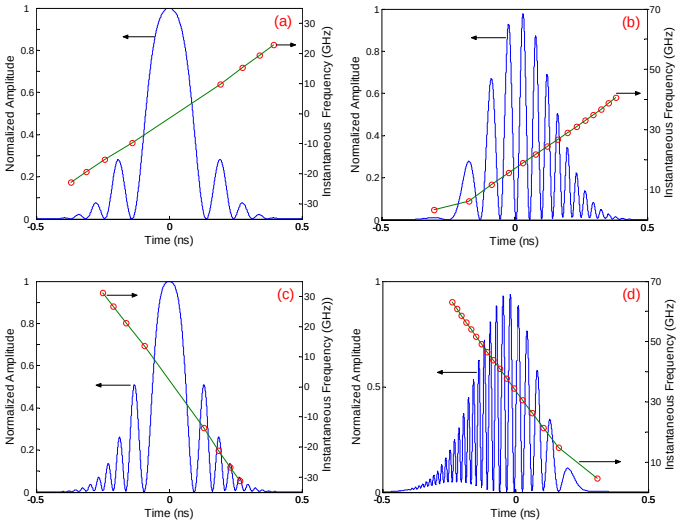
B. Nonlinearly chirped fiber Bragg grating



Without beam bending (Y=0) | With beam bending (Y=5mm)



3. NUMERICAL RESULTS



4. CONCLUSION

A novel approach to generating chirped electrical pulses with a tunable chirp rate using an NL-CFBG has been proposed and analyzed.

The NL-CFBG with an adjustable nonlinear group delay was fabricated using a regular linear chirped fiber Bragg grating based on strain-gradient beam tuning technique.

The frequency characteristics of the generated chirped electrical pulses can be easily tailored by adjusting the parameters of the optical system.

The proposed technique is simple, which can find wide applications in modern radar, communications and instrumentation systems.